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HOW TO MODEL OPERATIONAL RISK, IF YOU MUST

LECTURE TO THE FACULTY OF ACTUARIES

By Professor P. Embrechts

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Introduction

The second Lecturer to the Faculty of Actuaries is Professor Paul Embrechts, Professor of Mathematics at the ETH Zurich (Swiss Federal Institute of Technology, Zurich), specialising in actuarial mathematics and mathematical finance. His previous academic positions include ones at the Universities of Leuven, Limburg and London (Imperial College), and he has held visiting appointments at various other universities. He is an elected Fellow of the Institute of Mathematical Statistics, an Honorary Fellow of the Institute of Actuaries, a Corresponding Member of the Italian Institute of Actuaries, Editor of the *ASTIN Bulletin*, on the Advisory Board of *Finance and Stochastics* and Associate Editor of numerous scientific journals. He is a member of the Board of the Swiss Association of Actuaries and belongs to various national and international research and academic advisory committees. His areas of specialisation include insurance risk theory, integrated risk management, the interplay between insurance and finance and the modelling of rare events.

Summary of the Lecture

In the introductory part of his lecture Professor Embrechts outlined some of the recent developments in regulatory capital requirements under Basel II and Solvency II. He stressed how technically-minded actuaries could and do have an impact on developments in the banking sphere, as well as in insurance. As an example, he remarked that the Federal Reserve Bank in Boston had recently invited him to deliver a course on the latest techniques emerging from the field of insurance mathematics which could be applied to operational and other banking risks.

Under the new Basel II accord there are three pillars. The first of these is the most technical, involving the measurement of risk. The second and third pillars deal with the management processes which overlay the technical calculations and the public communication of results to stakeholders. Solvency II is now emerging as the equivalent approach in insurance, and is using many of the same ideas as Basel II. Professor Embrechts remarked that, prior to the introduction of Solvency II, different countries around Europe have progressed at quite different speeds, citing Switzerland as one country which is leading the way in the use of realistic calculation of risks and liabilities (Swiss Solvency Test). In banking the new accord requires explicit treatment of operational risk, and this was the focus of the remainder of his lecture.

Under Basel II, operational risk is defined as 'the risk of losses arising from inadequate or failed internal processes, people and systems or external events'. Operational risk is essentially all downside risk, and exists in insurance businesses as much as in banking. Examples of operational risk losses include Barings Bank, September 11, Enron, and Allied Irish Bank.

Professor Embrechts outlined three approaches to the measurement of operational risk. First, there is the Basic Indicator Approach, suitable for small banks, which has a capital charge which is a simple multiple of average annual gross income. Second, the Standardised Approach generalises this by applying different multipliers to different lines of business. Third, there is the Advanced Measurement Approach, which large banks and insurers might use to measure their risks more accurately, and this is the approach which requires the services of a good actuary.

Operational losses can first be categorised by line of business, and second by type of operational loss (e.g. internal fraud, external fraud, damage to physical assets, etc.). The loss under each line and type of operational loss (think of each as a cell in a matrix) is then the sum of the individual losses. At this stage we are looking at something which closely resembles losses on a portfolio of non-life insurance business. From a statistical perspective, each of these can be dealt with in exactly the same way, although their statistical properties will certainly differ significantly. The approach is based on risk theory, in which all of our students are examined. Risk theory covers a range of fat-tailed distributions for individual losses and a range of possible distributions for numbers of claims. In his experience, Professor Embrechts had: "never seen so much heavy-tailed data", and he continued with some remarks on the pros and cons of different measures of risk. Expected shortfall is a measure which is becoming more prominent, but he pointed out that it can be problematic when the tails of the loss distribution are very heavy.

Basel II has focused on the use of Value at Risk (VaR) as the standard risk measure. The intention is that the VaR should be calculated for each cell in the matrix, and then the individual VaRs should be added up to give an estimate for the total VaR of the institution. The question is: "Can we do better than this?" Adding VaRs is only accurate if the losses over all the cells are perfectly correlated. Usually this is not the case, so that we should be able to do better, and we might hope that there is some form of diversification effect which means that the true total VaR is rather less than the sum of the component parts. The situation is not so simple, however, and

Professor Embrechts gave two examples where the VaR calculated at the institution level is higher than the sum of the individual VaRs in each of the cells, even though the individual risks are independent. Expected shortfall avoids this problem of non-'subadditivity', but only works while the expected loss is finite. It is also to be remarked that the aggregation of VARs can be made, for instance, at the business line level.

Calculation of VaR or expected shortfall at the level of the institution relies on an analysis, at a basic level, of the correlation between the different cells; but, at a more detailed level, the dependencies between cells can be modelled in a better way using 'copulas'. One reason for thinking about the use of copulas is that they allow much greater control over the dependencies between individual risks. If the joint distribution is multivariate normal, then it is sufficient for us to know the linear correlation matrix. However, in many cases the degree of correlation changes as we move into the tails of the distribution. If we take two losses X and Y over the next year, we might be interested in the probability that both exceed some specified level z, or, given X exceeds z, what the probability is that Y also exceeds a specific (high) level z. The second of these is related to 'tail dependence'. With the bivariate normal distribution, tail dependence is zero. If we take a different view, that large losses all tend to happen at the same time, then we need to use a different joint distribution, or, more specifically, a different copula which gives us the required level of tail dependence.

Professor Embrechts showed the audience some plots which contained operational losses for a large financial institution over a period of about ten years (see Figure 1 in Chavez-Demoulin *et al.*, 2006). He noted that the data contained some huge spikes; individual, very large losses, pointing to a need for models of operational risk to use heavy-tailed distributions. Additionally though, he pointed out that there was a lack of uniformity in the data over time, reflecting the growing awareness of operational risk and changing practices in how the data are collected. Analysis of these data needs to take account of these changes over time. Having shown the plot of the individual losses, he then moved on to present the 'mean-excess plot' for the same data. The plot showed a rising and approximately linear trend; a clear indicator that the underlying data have heavy, Pareto tails. The fat-tailedness of the data suggested that, at the 0.1% level, one loss could cause the ruin of the company; a fact which he found extremely worrying.

In order to calculate, for example, VaR at high levels (e.g. 99% or 99.9%), Professor Embrechts stressed the need to have substantial quantities of data. Without the required quantity of data, the estimates of VaR and expected shortfall become subject to considerable parameter and model risk. Given the choice, therefore, he would recommend to regulators that they set their thresholds for VaR or expected shortfall at lower levels, where more reliable estimates can be calculated.

To conclude, Professor Embrechts reminded the audience that operational risk cannot be traded, it is made up only of losses, and it is extremely heavy tailed. So, actuarial methods for non-life insurance come naturally to mind. He reiterated that operational risk is substantial, and echoed a sentiment expressed by a regulator that the only way to get banks and insurers to model operational risk in a rigorous way is through regulation.

References

In addition to the work referred to in the summary of the lecture, the following list includes other publications which are suggested as further reading on the subject matter of the lecture.

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